Custom-Engineered Sol-Gel Materials

Sol-gel technology enables preparation of aerogels, xerogels, and glasses of specific compositions

An aerogel is a type of open cell foam with high surface areas and ultrafine pore and cell sizes. The unique microstructures result in the lowest thermal conductivity ever measured, making aerogels the world's best insulators. Aerogels are also good acoustic insulators and have low dielectric constants.

Our sol-gel researchers have pioneered the development of new aerogel materials. Sol-gel chemistry is a versatile approach used to synthesize unique materials with specific elemental compositions. It is a valuable preparation scheme if homogeneity is a key issue.

Preparation of aerogels and xerogels

Aerogels are prepared via sol-gel routes in which metal alkoxides are hydrolyzed and condensed to form a gel and subsequently dried under supercritical conditions to form lightweight porous solids. These aerogels, the lightest materials made, can be prepared over a wide density range (0.003 to 0.8 g/cm^2). Material can be made with a very high degree of homogeneity or with a graded density.

Xerogels are made by controlled evaporation of the liquid in the gel, which results in solids that are still porous and have half the theoretical density of the composite matrix. Both aerogels and xerogels can be sintered to full-density glasses at much lower temperatures than conventional melt processes.

APPLICATIONS

- *Cerenkov detectors*
- *Supercapacitors and dielectrics*
- *Chemical sensors*
- *Laser glass*
- *Catalyst supports*
- *Filters*
- *Thin films*
- *Thermal and acoustic insulation*
- *Micrometeoroid particle collectors*

Doped aerogels

We have prepared aerogels with dopants such as PMP, CAP, and a host of laser dyes, including fluorescein, rhodamine, pylokrome, and nile red. The lanthanide chlorides of erbium, mendelevium, praseodymium, and europium have been copolymerized with silica, resulting in transparent monolithic aerogels. Transition metals and the alkali and alkaline earth metals, such as copper, nickel, cobalt, palladium, iron, strontium, and rubidium, have been incorporated into silica matrices. The alkoxides of the transition metals of titanium, zirconium, vanadium, and tantalum have been cohydrolyzed with silicon alkoxide to prepare mixed aerogel systems and pure metal oxide aerogels, xerogels, and glasses. Boron and aluminum sols have been incorporated into gelling silica systems to produce composite aerogels with controlled porosity. Aerogels made using chain-substituted trimethoxysilanes can undergo further reactions, such as halogenation of a vinyl-alkyl group, and enable hydrophobic vs hydrophilic materials to be made.

We can tailor aerogels to fit specific applications—with different dopants and in various sizes and shapes.

Availability: We are interested in collaborating with industrial partners to improve the performance of their products using these potentially revolutionary materials.

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